DOCUMENT RESUME

ED 235 043 SE 043 336

AUTHOR Jones, Natalie; Hughes, Wyn
INSTITUTION University Coll. of North Wales, Bangor (United Kingdom). School of Educaton.
SPONS AGENCY Training Services Agency, London (England).
PUB DATE 82
NOTE 31p.
AVAILABLE FROM The Centre for World Development Education, 128 Buckingham Palace Road, London SW1W 9SH.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Botany; *Chemistry; Chromatography; Color; Cultural Activities; *Developing Nations; Elementary School Science; Foreign Countries; Intermediate Grades; Laboratory Procedures; Science Education; *Science Experiments; Secondary Education; *Secondary School Science; Wildlife
IDENTIFIERS *Dyes; *Third World Science Project; United Kingdom

ABSTRACT

This unit, developed by the Third World Science Project, is designed to add a multicultural element to existing science syllabi (for students aged 11-16) in the United Kingdom. The project seeks to develop an appreciation of the: boundless fascination of the natural world; knowledge, skills, and expertise possessed by men/women everywhere; application of knowledge and skills to solve the practical problems of everyday life; impact of modern technology in the world; and the influence of the cultural background on the perception of knowledge, problems, and solutions. The unit consists of six sections and list of references. Topic areas considered include: historical consideration of the use of color; natural dyestuffs in use today and their resources; and plant pigments (chlorophylls, carotenoids, anthocyanins, and anthoxanthins). Activities presented include: chromatographic analysis of plant pigments; preparation of colored solutions from natural sources; investigation of acidity/alkalinity; and an investigation of dye uptak (preceded by a discussion of dying fabrics). The unit concludes with a brief outline of tie-dying and print processes. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED235043

third world science

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

NATURAL DYES

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Lois Wyn Williams
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SE043336

THIRD WORLD SCIENCE

Third World Science seeks to develop an appreciation of:

1 The boundless fascination of the natural world

2 The knowledge, skills and expertise possessed by men and women everywhere

3 The application of knowledge, skills and expertise to solve the practical problems of everyday life

4 The impact of modern technology in the third world

5 The influence of the cultural background on the perception of knowledge, problems and solutions

The following Units have been designed to fit into existing science syllabuses in the United Kingdom:

CARRYING LOADS ON HEADS: CHARCOAL: CLAY POTS:
DENTAL CARE: DISTILLATION: ENERGY CONVERTORS:
FERMENTATION: HOUSING: IRON SMELTING: METHANE DIGESTORS:
NATURAL DYES: PLANTS AND MEDICINES: SALT: SOAP.

The method of use is not closely prescribed. As resources teachers may use them in different ways though suggestions are offered. Feedback is invited from teachers concerning (a) the use made of the material (b) pupils reactions, if possible in their own words, and (c) suggestions for improvements, additions etc.

Please send feedback, ideas and requests to:

Professor Iolo Wyn Williams
Third World Science Project
School of Education
University College of North Wales
BANGOR
Gwynedd, U.K.
Tel: 0248-51151

Copyright: Third World Science Project 1982

NATURAL DYES

Teacher's Notes

The arts of dyeing and patterning with dyes are very ancient, and since colour is such an important property of the materials we use for clothing and furnishing, it seemed worthwhile to include some consideration of the methods of obtaining dyes from natural sources and their application to fabrics by dyeing and printing. Obviously, it will only be possible to consider a bare outline of the dyeing process, but one or two of the properties of colour in fabrics can be established and a few simple experimental investigations of dyeing can be carried out.

The unit is introduced by a brief historical consideration of the use of colour followed by an account of natural dyestuffs in use today and their sources.

The section on Plant Pigments deals with an analysis of the chlorophyll and carotenoid pigments by paper chromatography, the anthocyanins and anthoxanthins. Coloured substances from natural sources can be prepared from rose petals, blackcurrants or almost any plant material to produce potential dyes. And by using the Universal Indicator the pH of the plant extract can be found.

It is impossible here to deal with the chemistry of the modern dyes or the dyeing processes in detail, but a brief consideration of dye uptake has been included which could lead to a useful pupil investigation of colour intensity, evenness of colour and fastness and retention of dye.

The unit concludes with a brief outline of Tie-Dyeing and Print Processes and obviously the scope to develop this section will depend on the imagination of the teacher. To this end a list of references for further information has been suggested.

NATURAL DYES

Contents

		Page
1.	Table illustrating some of the more important natural dyes	1
2.	Natural Dyes - a brief historical survey followed by an account of dyestuffs of plant and animal origin still in use	2
3.	Plant Pigments - chlorophylls, carotenoids.	8
	Investigating Chlorophyll Pigments	10
	Anthocyanins and Anthoxanthins	12
4.	Class Activity	13
	Preparing solutions of coloured substances from natural sources.	14
	Introduction to Acidity - Alkalinity	
5.	Dyeing fabrics	17
	Investigation of Dye Uptake - intensity of colour, evenness of colour.	18
	Fastness and Retention of Dye	21
	Tie-Dyeing	23
6.	Printing Processes	24
7.	References	25

NATURAL DYES

Although most of the natural dyes of antiquity have now little or no commercial use in modern industry, some are still in use in home industries and by handicraft workers. To this day, some of the natural dyes and pigments, e.g. Logwood, osage orange and Bitumen, retain much of their old importance.

The following table illustrates some of the more important natural dyes:

COLOUR	COMMON NAME	OCCURENCE	DYEING USE
YELLOW	Dyers Rocket	Reseda luteola L	Wool dyeing - best fast yellow
"	- -	Curcuma longa	Cotton, wool, silk
"	- -	Extract of safflower corella	Colouring of objects
"	Saffron	Crocus sativus L (Iris)	Textiles Food dye
"	Osage orange	Maclura pornifera	Wool, nylon, silk, leather
ORANGE	Annatto	Bixa orellana L	Cotton, wool, silk, foodstuffs and printing
RED	Cochineal	Coccus cacti L (insect)	Wool, foodstuffs
"	Barwood	Baphia nitida and Pterocarpus sanalinus L	Wool, cotton, Chrome leather and and foodstuffs
"	Brazin	Various species of Caesalpina	Cotton, wool,leather and biological staining
"	Dyer's Thistle	Carthamus tinctorius L	Textiles, flowers, food, cosmetics and pigments
BLUE	Indigo	Various Indigofera	Textiles
BROWN	Venetian Sumach	Rhus cotinus L	Textiles, leather
BLACK	Logwood	- - -	Most fabrics

NATURAL DYES

Until about 150 years ago most fabrics were coloured with dyes obtained from plant, animal, or mineral sources. But early in the 19th century chemists began to experiment with dyes made from various chemical compounds, notably *aniline*, which is extracted from coal tar. In the intervening years they have been so successful in developing substances that give lasting, vivid colours at low cost that plant dyes are now of only historical interest in the commercial world, though they are still used by craftsmen who work on a small scale or in remote places.

Most of the plant dyes come from wild-growing plants, for the quantities needed can usually be gathered without cultivating a crop. The dyes are found in various parts of the plants, from wood to leaves or fruits. The colour they yield depend much on the dyer's skill, and on the chemical *mordants*, such as *alum*, that fix (render insoluble) the dyes when they are applied to textiles, wood, or other materials.

Onion skins give orange colours, the roots of the madder plant (*Rubia tinctorum*), produce bright red, and the heartwood of the Siamese jack-fruit tree produces the brilliant yellow seen on the robes of Buddhist monks.

In northern countries, lichens are often gathered as sources of dyes; a yellow lichen found on the shore of the Scottish islands gives a rose-pink hue.

A few plants were formerly cultivated to yield dyes needed in quantity. Most important was indigo (genus *Indigofera*), believed to have originated in Indonesia. It belongs to the pea family (*Leguminosae*) and bears compound leaves and spikes of tiny reddish-yellow flowers. The dye is made from the leaves, which when left to ferment in water produce a paste that is dried to form the marketable product. This is colourless, and the deep blue shade appears only after the dyed fabric is exposed to air.

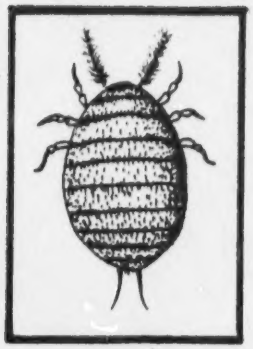
Woad (*Isatis tinctoria*) - a member of the mustard family - was once widely grown in Europe; at the time of the Roman Conquest it was used by British warriors as war-paint. The plant is raised from seed and bears bright-yellow flowers. Woad leaves have to be steeped in water before they yield the paste which after drying, re-wetting and further fermentation, gives a blue dye. Blue can also be obtained from privet, elderberries, bilberries and the silvery blue-green lichen that grows on old apple trees.

Woad

Man has always shown great ingenuity in his search for colours to express his ideas and feelings and to brighten his surroundings.

Dyes ought not to fade, either through cleaning or in sunlight; and the colour ought to be even throughout the cloth. This has always been the objective of dyers, but their industry is as old as spinning and weaving, and many of them in the past must often have fallen short of these standards. Their recipes of dye mixtures were usually trade secrets handed down from father to son, and there was a lot of experimentation with different colours and mixtures.

The first dyes were the juices of berries and fruits, extracts of crushed flowers, tree-barks, and certain roots. Doubtless they were discovered by the way they stained the hands of primitive people gathering food. Later, as trading become more widespread, more colours were discovered, some of them obtained from the bodies of insects, like the red of Kermes, the dried bodies of insects which feed on kermes oak, an evergreen of Southern Europe and North Africa. *Cochineal*, too, the bright scarlet once used for dyeing British guardsmen's tunics, is made from the dried bodies of cactus-eating insects from the East Indies and Mexico.



Cochineal insect
(Dactylopius coccus)

Red, blue, and yellow, the primary colours, were probably the first to be used, soon to be followed by the secondary colours of the rest of the spectrum. Alchemists often spent their time experimenting with colour changes because they believed that different colour meant a difference in basic substance.

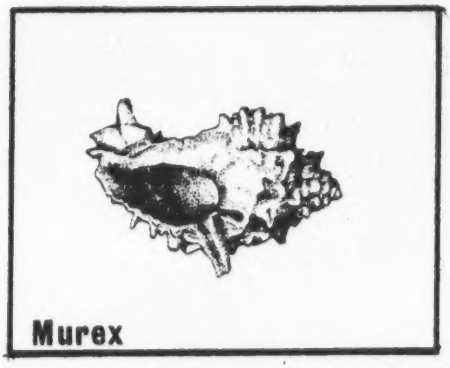
Dye stuffs are chemically linked to the fibres of the fabric. If they were not held 'fast' in this way, they would soon wash out. There are many methods of dyeing which vary according to the chemical nature of the dye and the fabric. All of them involve the use of dyes that are soluble in water. In direct dyeing, which has been possible for less than a hundred years, the fabric is simply boiled in a solution of the dye.

Mordant dyeing involves a third substance, usually an aluminium compound, which forms intermediate links between the fibre and the dye. Mordants (*biters*) provide surfaces on which dyes will hold fast. In vat dyeing, the fabric is soaked in a colourless solution of the dye and only when it is exposed to the air does the colour form.

Logwood

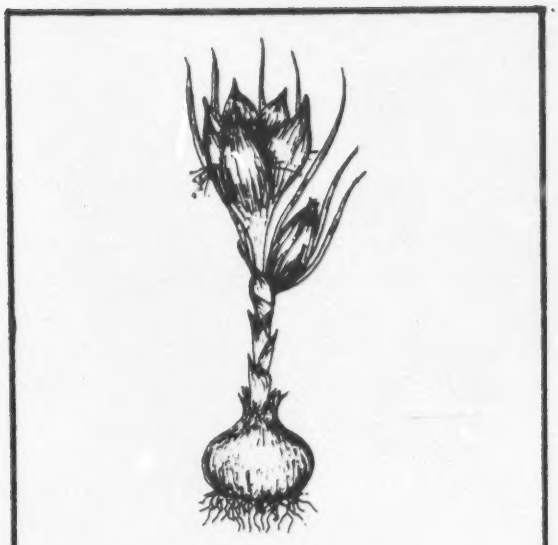
The art of using dyes to colour fabrics is almost as old as the art of painting. Great skill is needed, but despite the fact that success depends on chemical reactions that were not then understood, fine results were achieved. Some of the vegetable dyes were extremely 'fast', and, although there were only a few of them, a useful range of colours was made by mixing the dyes or by using various mordants. Nowadays, logwood is the only natural dye in widespread use.

Purple was an important colour for the people of the ancient civilizations. It was worn by kings and emperors because it was expensive. It had religious significance, too, and in the Christian church to this day it is the colour of mourning and penitence, worn ceremonially during Lent. The purple of ancient Tyre came from the gland that produced the slimy mucus of the purple snail, or *murex*, which is a sea-snail from the warm seas such



Murex

as the Mediterranean. Because Tyrenian purple was so expensive, other sources and substitutes were found, all of them, like most natural dyes, of vegetable origin. One source was *turnsole*, a plant so named because its leaves and flowers were believed to follow the direction of the sun. *Bryony berries, dandelion roots, and deadly nightshade*, also give a purple dye. Various *lichens* provided a violet dye called *archil*, and today mixtures of *lichens* scraped carefully off rocks and trees are still used to dye the wools that make some of the classic tweeds and knitted garments of the Hebrides and Shetland Isles. *Lichen dyes* are what give tweeds their typical smell. They are the most permanent of all natural dyes and were therefore used for the typical colours employed in Highland tartans.



Saffron

Yellow has always been obtained from *saffron*, the orange stigmas of the *autumn crocus*. The saffron robes worn by Buddhist monks are still dyed this way, and *saffron powder* is always used in cooking, sometimes to make cakes look rich in butter and eggs, and often to colour rice when it is the basis of a meat dish. Infusions of yellow flowers can also be used, such as *gorse, broom, and kingcup*. The ancients used the stems and leaves of *weld*, or dyer's weed, and *turmeric*, the root of an East Indian plant.

Black can be made by boiling *acorns, and oak bark* gives brown. The rinds of nuts were often used to make blacks and browns, and one of the most famous is *walnut* stain. *Soot* has also been used as a black dye; and *logwood*, an extract from the heart of a Central American tree, is still used today to make a deep, rich black.

Just as important as the dye is the quantity of the water in which it is mixed. The dyers' recipes of old often specify rainwater; many modern dye works are still situated in traditional dyeing districts where hillside streams or lakes supply clean, soft water in plenty. More than half those in Britain are located in Lancashire and Yorkshire, on both sides of the Pennine Chain, which is abundant with running water, and of course conveniently in the vicinity of the woollen mills to the east and the cotton mills to the west.

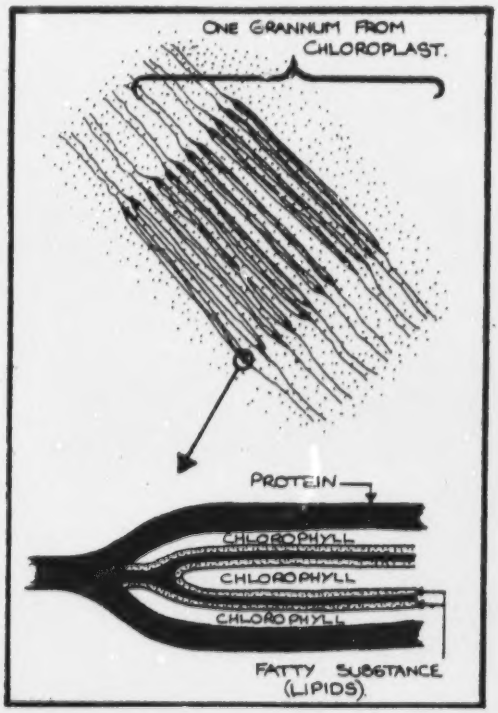
If yarns are dyed before weaving, they may be wound into hanks and suspended in the dye, or wound into hollow packages like big doughnut rings (called "cakes") which fit on to tubes of perforated metal through which the dye is pumped. Fabrics dyed in the piece - i.e. in lengths of many yards not yet cut for clothing - are given one or two dyeing treatments, depending on whether they crease easily.

Nowadays modern mass-produced materials are seldom dyed with vegetable extracts. Man-made chemical preparations have been increasingly used since the first synthetic dye was discovered in 1856, when an 18 year old research chemist called Perkin accidentally discovered a strongly coloured substance when he was trying to prepare the drug quinine from a colourless oily compound called *aniline*. He went on to find ways of applying his discovery to textiles, and today *aniline* is the base of most synthetic dyes. Originally it was a distillation of *indigo*, but William Henry Perkin extracted it from *coal tar*. Perkin proceeded to manufacture the material, and his great contribution was the production of an 'artificial' dye in quantity. Called *aniline purple, or mauveine*, it became immensely popular. Clothing dyed with it was the height of fashion. Later on it was used to dye the 'lilac' postage stamps of the period.

A great industry grew up producing synthetic dyes from the organic chemicals found in coal tar. Tens of thousands of dyes have been synthesised and thousands of these are produced commercially. The best part of 30 years had been spent to find a way of making a synthetic indigo that could compete in price with the natural product and the cost of research was very great. But by the end of the 19th century, synthetic indigo could be sold for less than the natural product.

PLANT PIGMENTS

The green pigment *chlorophyll*, an indispensable requirement for photosynthesis, is located within the *chloroplasts*. In higher plants these are disc-shaped bodies, about 5 μ across. They are very numerous in the mesophyll cells of leaves which may contain as many as 50 to 100 per cell, but less abundant in guard cells and the outer cells of aerial stems; many cells - as in the root - lack chlorphyll altogether. Some algae such as *Chlorella* have one large chloroplast per cell. The pigment is not uniformly distributed within the chloropast but confined to regions known as *grana* of which there are from 10-100 in each angiosperm chloroplast.



There are two types of pigment contained in chloroplasts viz: the green ones which are the *chlorophylls* and the yellow *carotenoids* which are associated with them. In addition to these, some leaves such as those of the copper beech contain *anthocyanins*, which are water-soluble and situated in the vacuole and therefore not chloroplast pigments. All chloroplast pigments are hydrophobic in nature i.e. not water-soluble, and can be extracted from fresh or powdered dried leaves with 90% acetone. As a result, a mixture of chloroplast pigments is obtained.

The individual components of this mixture may be seperated out by taking advantage of their different solubilities in various solvents, but a more elegant procedure is that of chromatography.

The pigments present in photosynthetic plants can be separated by means of paper chromatography. Minute quantities of closely related substances can be isolated and studied by this method.

Chlorophyll a and chlorophyll b are the two chlorophylls to be found in leaves, and are organic substances with a similar complex ring structure and a central atom of *magnesium*. It is thought that the chlorophyll molecules in the chloroplast are closely associated with protein (see diag. p.8). A green-blue colour is shown by a weak solution of *chlorophyll a*, whereas a more yellowish-green is shown by a solution of *chlorophyll b*. This colour reaction results from the absorption of light at the blue and red ends of the spectrum. The molecular formulas of these two chlorophylls shows that they are complex molecules made up of 5 different kinds of atoms:

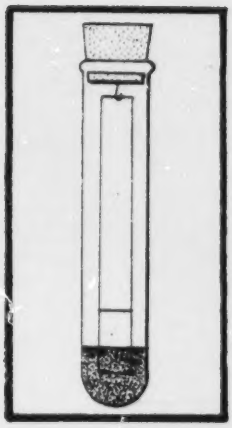
Chlorophyll a: $C_{55}H_{72}O_5N_4Mg$

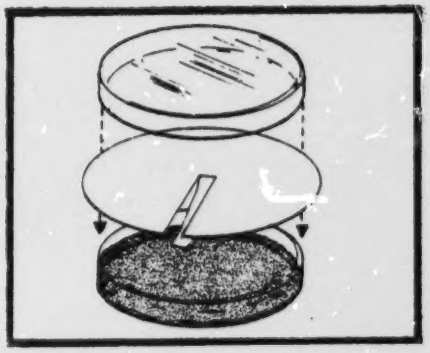
Chlorophyll b: $C_{55}H_{70}O_6N_4Mg$

The *carotenoids* are yellow pigments, absorbing light mainly at the violet end of the spectrum. They include the *carotenes* and the *xanthophylls*. They are present in chloroplasts and also in the plastids of some non-chlorophyllous cells such as the perianth of *Cheiranthus* (wallflower), the root of *Daucus* (carrot), and the fruit of *Lycopersicum* (tomato).

The *carotenes* are all isomeric hydrocarbon oils with a formula $C_{40}H_{56}$. They are probably polymers of *isoprene*. The 3 best known are α- *carotene*, β - *carotene and lycopene*. The α- and β - *carotenes* are present in green plant tissues and probably play a small part in photosynthesis, but are considerably less efficient than chlorophyll. *Lycopene* is the colouring material of tomatoes and certain other fruits.

Xanthophylls are *hydroxy, ketone, aldehyde or carboxylic acid derivatives of carotenes*. The commonest is *lutein*, found in green leaves. The colours of most yellow and orange flowers, of some fruits and seeds, and of yellow leaves, are due to *carotenoid* pigments in chromoplasts.





Methods for paper chromatography.

Materials

Green leaves	Test tubes (standard size)
Alcohol	Hot water bath
Wire hooks	Fine-tipped pipette
Scissors	Large test tube and cork, or petri dish
Solvent mixture	Filter paper (strip or disc)

Method

1. Place a few leaves in a test tube. Pour in enough alcohol to cover the leaves. Place the tube in a hot water bath. Boil the alcohol for a few minutes until it becomes deep green, almost black. This is the pigment extract.
   CAUTION: Do not expose alcohol to an open flame.
2. Attach a strip of filter paper to a cork. You can use tape or push a paper clip into the cork. Or, you may use a small wire hook, shaped like a "J". Push the long end of the hook into the bottom of the cork and then hang the paper strip on the hook. Make sure that the paper hangs straight in the tube and almost reaches the bottom. (see above).
3. Take out the cork and paper and pour enough solvent mixture (acetone, ethanol) into the tube so that the bottom of the paper strip will dip into the liquid when the paper is put back.

4. In pencil, not ink, draw a line across the paper strip about 2 cm from the bottom of the strip. Along this line spread a drop of the pigment extract with a fine-tipped pipette or a glass rod. Allow the paper to dry thoroughly. Then add another drop of pigment extract along the pencil line and allow it to dry. Repeat a few times until the line of colour is dark green.

5. Place the paper with the line of dried pigment extract in the test tube. Be sure that the bottom of the paper dips into the solvent mixture, but try to keep the paper from touching the sides of the test tube. Allow the solvent mixture to rise almost to the top of the paper strip. Then make notes and sketches of your observations.

6. Another method of paper chromatography that produces equally good results uses a disc of filter paper slightly larger that a petri dish. If you wish to try this method, cut 2 parallel slits, about 5 mm apart, from one side of the paper disc to the centre. (See diagram). Fold the cut strip down. Then place the pigment extract, a drop at a time, along the fold at the centre of the paper. Pour solvent into the bottom of the petri dish - as shown in the diagram - with the cut-out strip of paper dipping into the liquid. Place the cover of the petri dish on top of the paper. Allow the *chromatogram* to develop during the rest of the period. Record your observation.

Discussion

1. List the colours in order from the top to the bottom of the strip, or from the outer edge to the centre of the disc.

2. Each colour is due to a different kind of pigment substance. Identify the names or chemical make-up of the different pigments on your chromatogram.

Anthocyanins and Anthooxanthins

The red, blue or violet pigments which occur in solution in the cell sap of many flowers, fruits, stems and leaves are due to the presence of *anthocyanins*. These are all glycosides of the sugars *glucose, galactose and rhamnose*. When *anthocyanins* are hydrolysed they give *sugars, an anthocyanidin*, and other residues. The varied number of *anthocyanins* are derived from 3 *anthocyanidins - pelargonidin, delphinidin, and cyanidin.*

The *anthoxanthins*, on the otherhand, are practically colourless and are present in many white and some yellow flowers. They are chiefly glycoside derivatives of the benzopyrone nucleus.

Senescence is the term applied to the last stage of plant life, being followed by death and autolysis of cells. The first pigments to disappear are the green chlorophylls which previously masked the underlying yellow *carotenoids;* this colour change to yellow is evident in many leaves, citrus fruits and in banana. Sometimes - as in many leaves e.g. Virginian creeper, some apples etc. - the red *anthocyanin* pigments are synthesised as the chlorophyll disappears.

During the ripening or senescence of fleshy fruits e.g. banana - the softening of the fruit is caused by changes in the pectic substances of the cell walls; a distinct odour develops and the starch becomes converted to sugar.

NATURAL DYES

Class Activity

1. Collect specimens of as many different colours as you can find and arrange them in columns in a scrapbook. In one column, list examples of stains from any natural dyeing materials you can collect in woods and fields. Use the next column for samples of materials coloured with modern chemical dyes. In the third column, paste or paint examples of pigments. These come more often from mineral rather than vegetable sources, and you may find many of the specimens you need among your oil and water colour paints, or in coloured inks.

2. Supply your wall map with little gummed discs on which you have sketched and named the plants, trees, flowers, and insects from which natural dyes are obtained. Stick the discs in or near the countries where the materials grow. Use some smaller discs of the same colour to indicate some of the centres of the dyeing industry.

3. Following the section on Plant Pigments it could be suggested that each pupil takes home a test-tube with a cork in it and brings it back for the next lesson filled with the coloured extract (or juice) of a vegetable, fruit,or flower. A wide variety of substances is suitable and the choice will depend on the time of year and the location of the school. The coloured substances extracted from the plants can be used to introduce a lesson on acidity - alkalinity. The following two experiments could therefore be undertaken.

EXPERIMENT 1

To prepare solutions of some coloured substances from natural sources

Flowers, fruits, and vegetables which make good indicators are:

Delphinium flowers
Blackcurrants
Rose petals of various colours
Red cabbage leaves
Blackberries
Beetroot

Method

First crush the plant material with a pestle and mortar and then grind it up thoroughly with a mixture of equal volumes of industrial methylated spirit and water. You will require a quantity of this mixture between 5 and 10 times the weight of the plant material being used.

Transfer the material to a round-bottomed flask (which should not be more that half filled) and add 2 or 3 pieces of broken porcelain or pumice stone to ensure even boiling. Insert a condenser vertically in the flask, and reflux the contents gently over a boiling water bath until it can be seen that the solid parts of the mixture have become 'white'. This should take about 20 minutes.

Allow to cool and then filter to obtain the coloured extract.

Introduction to Acidity - alkalinity

An acid contains hydrogen that can be replaced by a metal, and the resulting compound is called a salt. An acid also turns blue litmus red.

Other characteristics common to most acids are the following:

1) They have a sour taste - the sour taste of lemons, unripe apples, and vinegar, is due to the acids they contain, *citric* in lemons, *malic* in apples, and *acetic* acid in vinegar.

2) They not only turn *blue litmus red* but affect the colour of other substances. Such substances which change colour when acids are added to them are known as *indicators*. In addition to litmus two other indicators which are commonly used are *methyl orange* and *phenolphthalein;* the colour changes of these 3 are summarised below.

Indicators	Colour in (a) Acid	(b) Alkali
Litmus	Red	Blue
Methyl Orange	Red	Yellow
Phenolphthalein	Colourless	Red

An interesting example of this sort of change is the behaviour of a pickling cabbage. The leaves of the cabbage are purple when growing but red when pickled. This is because they contain an indicator (*anthocyanin*) which is purple when the alkaline sap is present in the growing plant but red in the presence of the acid vinegar.

3) They will attack carbonates and bicarbonates to liberate carbon dioxide which can easily be recognized by its effect on limewater. This simple test is often applied using washing soda (sodium carbonate) or bicarbonate of soda; if there is an efferescence when a liquid is added to one of these two, then it contains an acid

4) They lose all their acidic properties when they are neutralised by a *base* to form a *salt* and *water*.

A base is a substance that will react with an acid to from a salt and water only.

The rough pH value of a solution can be found by means of a *Universal Indicator* which is a mixture of indicators, so designed that its colour

changes approximate to the colours of the spectrum as the pH changes from 3 to 11

pH	Colour of indicator	pH	Colour of indicator
3	pink	7-7.5	greenish-yellow
4	red	8	green
5	orange-red	9	greenish-blue
6	orange-yellow	10	violet
6.5	yellow	11	reddish-violet

The pH scale may therefore be used to express the degree of acidity and alkalinity, alkalinity being at this stage simply the property of any solution which has a pH greater than 7. A solution of pH 7, which is the 'acidity' of pure water, is called a *neutral* solution.

Experiment 2

By using the Universal Indicator find the pH of the extract of plant materials prepared in experiment 1, and of some common materials such as toothpaste, lemonade, soap, tap water, and asprin.

Make a chart showing the pH of the plant extracts and these common substances.

Dyeing Fabrics

Colour features quite prominently in the materials that we use for clothing and in furnishing our homes, and so it seems appropriate to include some information about the methods of dyeing and printing in order to apply colour to fabrics. Only a brief outline of the dyeing process can be considered here with a few simple experimental investigations.

One of the most essential characteristics of colour is that it should be *fast* i.e. it must be able to withstand the effects of sunlight and washing. If this requirement is not satisfied and the dye will not adhere to the fabric, then for obvious reasons it will be rejected.

Colours can be extracted from a variety of plant materials e.g. rose petals, blackcurrants etc. In earliest times plant sources which produced dyes included logwood (*logwood tree*), indigo (*woad*), and alizarin (*madder plant*). Others were extracted from the crushed bodies of insects e.g. cochineal.

Pupils will be familiar with deeply staining materials such as beetroot, blackberry juice and inks, and these could be used as potential dyes. They could afterwards test their suitability as dyes at the same time as the genuine dyes.

Pupils should be made aware of the fact that the introduction of new man-made fibres e.g. *rayon, nylon, terylene, and orlon* has made the technique much more difficult. There is no certainty that a dye which can be applied with success to cotton or wool will have the same results for one of these fibres. The pupils will no doubt be aware of the fact that many modern fabrics are the mixtures of two fibres e.g. *wool and nylon*, which makes the dyer's task much more difficult.

Investigation of Dye Uptake

For this investigation a few samples of white material, about 5 cm square will be required e.g. wool, silk, cotton, nylon, terylene, courtelle, and acetate. The intensity and evenness of colour can be compared when samples are dyed in various ways.

It will become apparent that some materials are easier to dye than others and the man-made fibres will be notably difficult. In this investigation, aim to find the most effective method of dyeing each fabric. Although there are many methods of dyeing, two of the oldest and easiest are considered here. Results obtained with these methods, *direct and mordant* dyeing , are compared with a third method using a proprietary multi-purpose dye.

The following dyes are easily obtainable: *congo red, primulene, alizarin, and methylene blue.* Natural dyes from plant sources can also be used: yellow from *marigold,* orange from *onion skin,* purple from *damson,* red from *blackberry etc.* Plant dyes can be extracted by boiling the crushed fruit or chopped plant with water.

Requirements and Method

a) *Direct dyeing*

The sample is first treated with dilute (M10) hydrochloric acid to remove any size etc used as a finish. The material is then rinsed before boiling for 10 minutes in the dyestuff solution, made up as follows:

2g of the dyestuff (*methylene blue or cogo red*)

4g of Sodium Sulphate

8g of Sodium Carbonate

Mix the ingredients well and add to 500 ml of distilled or de-ionised water. The dye samples are dried and compared for intensity and evenness of colour.

b) *Mordant dyeing*

Ammonium sulphate is used as a mordant to make the dye 'bite' on to the fabric. Firstly, soak the samples in a 10% solution of the mordant and then heat gently for 15 minutes. Remove the samples and allow to stand in dilute ammonium chloride for a few minutes before thoroughly rinsing in water. Boil the mordanted samples in the dye for a short time, preferably the same period used in (a), so that the results are more easily compared.

c) *Proprietary dyestuff*

A tremendous variety of dyes are manufactured to cater for the requirements of the different fabrics that are available today. Consequently, the production and use of a multi-purpose dye-product is more popular now as it suits every kind of fabric. The following precautionary measures should be observed during the dyeing process:

i) Ensure that the dyestuff has been thoroughly dissolved.
ii) Use a container which is large enough to accommodate sufficient dye to cover the fabric.
iii) Ensure that the material samples are thoroughly 'mixed' in the dye solution.
iv) Evenness of dye absorption into the fabric can be improved with the addition of sodium chloride.
v) Make certain that the fabric is thoroughly saturated during the dyeing process.

Suggested fabrics for use:

5 cm square white material samples of wool, silk, cotton, terylene, courtelle, and acetate.
(Use white material to avoid the necessity of having to bleach out the colour beforehand).

After completing your investigations, tabulate your results as suggested on page 20.

Results

Intensity of colour

	Wool	Silk	Cotton	Nylon	Terylene	Courtelle	Acetate
Direct dye Mordant dye Proprietary							

Evenness of colour

	Wool	Silk	Cotton	Nylon	Terylene	Courtelle	Acetate
Direct dye Mordant dye Proprietary							

The most satisfactory material will have the column with the most ticks. After studying your results, answer the following questions:

1. Consult your results - which is the best general method of dyeing?
2. Synthetic fibres are difficult to dye - which dyeing procedure is best for them?
3. Is there any variation in the different colours used to dye? Do some shades impart colour easier than others?
4. Why do some fabrics dye easier than others?
5. From your results - decide which is the most important stage in the dyeing process.

If time allows, a more detailed investigation could follow on intensity of colour, other dyeing methods, different mordants etc.

Fastness and Retention of Dye

Expose the samples of material dyed earlier to washing, sunlight and ironing, and subject some commercially dyed fabric to the same treatment. In order to assess the amount of dye fastness and retention - compare the treated sample to the original.

Test Requirements

1. Wash your 5 cm square samples with:
   (a) Soap based powder.
   (b) Powder based on synthetic detergent.

   After the samples have been rinsed and dried, they are compared with the unwashed sample. Observe the colour of the washing water and decide whether any dye has been lost.

2. Expose some samples of fabric to sunlight for three weeks , or to an ultra-violet lamp for six hours.

3. Iron the dyed samples whilst damp on to a piece of white paper until the dye transfer has ceased. Ensure that the iron is cleaned carefully afterwards. Compare the loss of colour, if any, when dry with a 'control' sample.

Tabulate your results as indicated in the columns below:

Direct Dyed

	Cotton	Wool	Silk	Nylon	Terylene	Courtelle	Acetate
Washed (a)							
(b)							
Sunlight							
Ironed							

xxx Distinct loss of colour x Slight loss of colour

\+ Dye fast

Use your 3 result tables viz: intensity of colour, evenness of colour, and fastness and retention of dye, to answer the following questions:

1. In your opinion, which dyeing procedure gives the fastest colours?
2. Which material holds the dye best of all?
3. If many shades of colour are used - which of the colours 'run' most easily?
4. Decide which of the 3 treatments - washing, exposure to sunlight or ironing - has the most harmful effect on the dye.
5. You may find that some dyes are faster to some materials than others - why is this?

Tie-Dyeing

Besides dyeing a piece of fabric evenly all over (plain dyeing), there are processes by which a patterned effect is achieved by dyeing some areas of the fabric and leaving the rest the original colour.

Tie-dyeing is a primitive craft still practised in West African countries. Woven cotton is pleated and stitched in various ways, and shells, pebbles, seeds, fastened in according to whatever traditional design is being followed. The piece of fabric is then alternately dipped in an indigo vat and hung in the air until the full dark blue colour has developed.

When the tying or stitching thread has been removed, the pattern emerges as that part of the fabric which the dye has not been able to penetrate.

It is important to bind and tie very tightly, and to saturate the fabric with cold water before dyeing, to prevent the dye from penetrating too much.

Suitable dyes are: *Procion*
Dylon (Hot and Cold)
Indigo Vat
Permanganate of potash

Printing Processes

The most widely used method of decorating fabrics is printing. In the early days of the craft, printing was done by hand with wooden blocks. Now most of our dress and furnishing fabrics are printed mechanically on metal rollers and vast quantities are being turned out daily. Even the traditional designs of tie-dying and batik are often reproduced in this way, and exported to the countries where the designs originated.

Block Printing

Block printing by hand over a large area can be a tedious occupation, but the knowledge of design gained from experimenting with small units can be very valuable, and there are many uses for short lengths of patterned fabric. Very simple basic equipment is needed for working in this way.

Many objects in everyday use, corks, cotton reels, india rubber, pencils, matchsticks, etc., can be used to print interesting shapes and textures. The printing surface should be slightly absorbent in order to pick up enough dye to register.

NATURAL DYES

References

1. Chemistry Background Books - Colour - pub. Nuffield Foundation
2. Man and Plants - H.L. Edlin
3. What we all Wear - Owen Webster
4. Biological Science - Molecules to Man - Biological Sciences Curriculum Study
5. Biological Science - An Inquiry into life - Biological Sciences Curriculun Studies
6. Lowson's Textbook of Botany - revised by Simon, Dormer, Hartshorne
7. Plant and Animal Biology - Vol. II - Vines and Rees
8. Nuffield Secondary Science - Using Materials
9. Simple Experiments in Textile Science - Ridley and Williams
10. Simple Textile Dyeing and Printing - Nora Proud

Further Information

1. Lichens for Vegetable Dyeing - Eileen Bottom
2. Contemporary Batik and Tie-Dye - Dona Z Meilach
3. Dyeing and Printing - Beryl Ash and Anthony Dyson
4. Present-Day Craft - Anne Maile
5. Tie-and-Dye Make Easy - Anne Maile
6. Using fabrics for fun - Alice White

ACKNOWLEDGEMENTS

The Third World Science Project has been supported by a number of agencies and has drawn upon the expertise and goodwill of a vast number of individuals.

Pilot Project 1979-80 supported by the Overseas Development Fund

Writers: Trevor Roach, Philip Bladon Typing: Carole Johns
Graphics: George Robinson

Main Project 1981-82 supported by the Manpower Services Commission

Writers: Natalie Jones, Wyn Hughes Typing: Marjorie Eccles
Graphics: Karen Moss

In this phase of the project 100 sets of 14 Units have been produced and distributed to schools, teachers' centres and teacher training establishments. Draft material has been prepared for further Units.

Dissemination 1982-3 supported by the University of Wales

Faculty of Education Research and Publications Fund

Printing: University College of North Wales Print Unit

Distribution: The Centre for World Development Education,
Buckingham Palace Road, London SW1W 9SH

The continued support and encouragement of Mr Dick Meakins of the CWDE is gratefully acknowledged

Sources The ideas and information incorporated in these Units come mainly from science teachers who are, or have been, teaching abroad. In some cases their pupils have also contributed. Some are known to us personally, others only through their letters, articles and books. We are very grateful to them all.

Wherever possible authors of published material and copyright holders have been approached for permission to reproduce extracts from their work. Where it has been impossible to trace the authors, apologies are offered.

For further information please contact

Professor Iolo Wyn Williams
Third World Science Project
School of Education
University College of North Wales
BANGOR, Gwynedd, U.K.

Copyright: Third World Science Project 1982